



Chemistry in War: Unveiling the Dual Nature, Challenges, and Paths to Responsibility

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Abstract

This paper discusses the relationship between war and science. Chemistry, the science of matter and its interactions, has had a profound impact on the history of warfare. It has been used to create, enhance, or counter various weapons and technologies, as well as to treat, prevent, or cause diseases and injuries. In this paper, we will explore some examples of how chemistry has impacted war in positive and negative ways and discuss the implications and challenges of using chemistry for war purposes. The use of chemistry in warfare has also had significant environmental, social, and ethical implications. As a powerful tool with the potential for both creation and destruction, chemistry demands responsible and ethical use. Balancing progress, responsibility, and ethics in the realm of chemistry is crucial for shaping a future where scientific advancements contribute to peace, sustainability, and the betterment of society.

Keywords: Ethical implications; Positive and Negative impact; War.

1. Introduction

War is a state of usually open and declared armed hostile conflict between political groups, such as states, nations, or factions. War involves the use of organized violence, coercion, and force to achieve political, economic, social, or ideological goals. War can also have political, economic, social, or cultural consequences, such as changes in power, alliances, borders, institutions, norms, and values. War can also affect the development, security, and stability of regions and the world. The relationship between war and science is complex and interdependent. Science can both enable and constrain war, and war can both stimulate and hinder science. Science can provide war with new technologies, such as weapons, vehicles, communications, and medicine, that can enhance the capabilities and efficiency of the military. War and science can also influence each other's goals, values, and cultures, as war can shape the direction, relevance, and responsibility of science, and science can shape the strategy, ideology, and morality of war. Science and warfare exist in a nexus of dependencies and possibilities. Science may be defined as organized knowledge and warfare, as organized violence. But warfare generates chaos, leading to unpredictability, uncertainty, and even

irrationality. Science is linked with the war system in several ways: by research funding, the direction of technological change, the criteria for important scientific problems and the structure of the scientific community. Science can provide war with new technologies, such as weapons, vehicles, communications, and medicine, that can enhance the capabilities and efficiency of the military. Militaries consume enormous amounts of fossil fuels, which contributes directly to global warming. It is important to consider the ethical, legal, environmental, and humanitarian implications of science and warfare, and to ensure that science is used for peaceful and constructive purposes. Science and warfare have a complex and interdependent relationship. Science can both enable and constrain war, and war can both stimulate and hinder science. Science can provide war with new technologies that can enhance the capabilities and efficiency of the military. However, science can also impose limits on war, such as ethical, legal, environmental, and humanitarian norms, that can restrain the use and impact of violence. Chemistry, the science of matter and its interactions, has had a profound impact on the history of warfare. It has been used to create, enhance, or counter various



weapons and technologies, as well as to treat, prevent, or cause diseases and injuries. Chemistry has also influenced the environmental, social, and ethical aspects of war and peace [1-4]. This paper illustrates some examples of how chemistry has impacted war in positive and negative ways and discuss the implications and challenges of using chemistry for war purposes. Chemical warfare is one of the most notorious examples of the use of chemistry in warfare. Chemical weapons are designed to inflict harm on humans, animals, or plants by using toxic chemicals. However, despite these prohibitions, chemical weapons have been used in several conflicts throughout history, causing widespread death, injury, and environmental damage. Chemistry has also played a significant role in the development of other weapons and technologies. For example, chemistry has been used to create explosives, propellants, and incendiaries, which have been used in various forms of warfare. Chemistry has also been used to develop new materials, such as polymers and ceramics, which have been used in armour, vehicles, and other military equipment. While chemistry has been used to create weapons and technologies, it has also been used to treat and prevent diseases and injuries caused by warfare. For example, chemistry has been used to develop antibiotics, vaccines, and other medical treatments that have saved countless lives. Chemistry has also been used to develop protective gear, such as gas masks and body armour, which have helped to reduce the risk of injury and death in combat. The use of chemistry in warfare has also had significant environmental, social, and ethical implications. Chemical weapons have caused widespread environmental damage, including soil and water contamination, which can persist for decades or even centuries. The use of chemical weapons has also raised ethical concerns about the use of weapons of mass destruction and the indiscriminate harm they can cause.

2. The Positive Impact of Chemistry in War

The landscape of warfare has long been intertwined with scientific advancements, and chemistry has played a pivotal role in shaping the trajectory of medicine, military technology, and environmental protection during times of conflict. This

comprehensive exploration delves into how chemistry has been instrumental in the development of life-saving medicines and treatments, the creation of innovative materials and technologies for military operations, and the mitigation of environmental damage caused by war. **Medicine and Treatment:** The historical alliance between chemistry and medicine has yielded profound breakthroughs, significantly impacting the outcomes of wartime injuries and diseases. Alexander Fleming's discovery of penicillin in 1928 stands as a watershed moment, revolutionizing the treatment of bacterial infections, including those arising from war wounds. Penicillin's widespread use during World War II saved countless lives by preventing infections that would otherwise have been fatal. Beyond antibiotics, chemistry has provided potent pain relief in the form of morphine, a substance with centuries-long utilization to alleviate the severe pain associated with injuries and surgeries. In war zones, where pain management is critical, morphine continues to play a crucial role in enhancing the well-being of wounded soldiers. Quinine, a natural alkaloid extracted from the cinchona tree, emerged as a vital antimalarial drug during World War II, showcasing how chemistry combats the health threats posed by wartime environments. The development of synthetic antibiotics like sulphonamides in the 1930s further exemplifies chemistry's role in treating bacterial infections during wartime. These synthetic compounds, extensively used in World War II, continue to be relevant in modern medicine, underscoring the enduring impact of wartime chemical innovations. Additionally, vaccines, biological preparations stimulating the immune system to produce antibodies against specific diseases, have been instrumental in preventing and controlling infectious diseases such as smallpox, polio, and influenza in war zones. The expansive contribution of chemistry to medicine during wartime extends far beyond the mentioned examples. Continual advancements underscore the discipline's vital role in enhancing human health and well-being amid the challenges posed by armed conflicts. **Materials and Technologies:** In the realm of military operations, chemistry has been a driving force behind

the creation of new materials and technologies, enhancing both efficiency and safety. The 1934 patent by Leo Szilard for a nuclear fission reactor laid the groundwork for the development of nuclear power plants and submarines, demonstrating how chemistry has transformed the energy landscape for military and civilian purposes. The advent of nuclear energy not only provides a clean and reliable source of electricity but also offers strategic advantages in naval operations. During World War II, chemists Fritz Hofmann and Waldo Semon pioneered the development of synthetic rubber, a critical innovation driven by the scarcity and costliness of natural rubber. This synthetic alternative became indispensable for manufacturing tires, hoses, belts, and other essential components for vehicles and machinery, thereby alleviating wartime shortages. Fuel cells, electrochemical devices converting chemical energy into electrical energy, represent another frontier in military technology influenced by chemistry. Widely employed to power military vehicles, drones, and various equipment, fuel cells offer enhanced efficiency and environmental friendliness compared to traditional combustion engines. Environmental Protection: Chemistry has also emerged as a crucial ally in mitigating the environmental repercussions of war. Chemical treatment, a process utilizing chemicals to neutralize or transform hazardous waste, provides an effective solution for substances that cannot be incinerated or landfilled. An exemplary case is the use of ammonia to safely neutralize the toxic gas hydrogen cyanide (Zyklon B), employed by the Nazis during World War II in gas chambers. This chemical reaction results in harmless compounds like water and ammonium cyanide, highlighting chemistry's potential to remediate environmental hazards. Another innovative approach is the utilization of biodegradable explosives, composed of organic materials like sugars, starches, and cellulose. Designed to minimize the environmental impact of detonations, these explosives decompose into carbon dioxide, water, and nitrogen, offering a sustainable alternative to traditional explosives with long-lasting ecological effects [5-7].

3. The Negative Dimensions of Chemistry in War

While chemistry has undoubtedly been a force for good, propelling advancements in medicine, technology, and environmental protection, it has a darker side. The negative impacts of chemistry on war are starkly evident in the creation of weapons of mass destruction and chemical warfare agents. From the devastating effects of chemical and biological weapons to unintended consequences and resource exploitation, the role of chemistry in warfare carries profound implications for both humanity and the environment.

3.1. Weapons of Mass Destruction and Chemical Warfare

Chemistry's dark side is epitomized by its contribution to the development of weapons of mass destruction and chemical warfare agents. Throughout history, these weapons have been used with devastating effects on ecosystems and human lives. Chemical and biological weapons (CBWs) have been deployed by both state and non-state actors to inflict infectious diseases, such as plague and smallpox, on enemies during wars. Nerve agents like sarin gas, mustard gas, chlorine gas, and even nuclear weapons have been employed to cause mass casualties, long-term health effects on soldiers and civilians, and lasting damage to the environment. Sarin gas, invented by IG Farben in 1938, is a nerve agent capable of causing death by suffocation, convulsions, and paralysis within minutes of exposure. Used by Nazi Germany in World War II, Iraq in the Iran-Iraq War, and terrorists in Japan in 1995, sarin is not only a potent weapon but also a water and food contaminant with hazardous effects on marine and freshwater ecosystems. Mustard gas, widely used during the First World War, disabled enemy combatants while contaminating lands and groundwater, indirectly affecting civilians. Nuclear weapons, based on nuclear fission or fusion reactions, are the most destructive ever created, causing massive explosions, fires, and radiation. The use of atomic bombs by the US against Japan in 1945 resulted in catastrophic consequences, including radiation sickness, cancer, and genetic mutations spanning generations. Even the dismantling of

chemical weapons poses environmental risks, illustrating how the very act of disarmament can have unintended consequences.

3.2.Unintended and Long-Term Consequences

Chemistry's impact on warfare extends beyond the immediate battlefield, manifesting in unintended and long-term consequences. During the Vietnam War, the US military deployed Napalm and Agent Orange to destroy forests and deprive Viet Cong guerrillas of vegetation cover. The aftermath witnessed millions of acres of destroyed land, thousands of livestock deaths, and public health problems in Vietnam due to increased susceptibility to diseases in defoliated areas. The potential consequences of a nuclear war are equally alarming, with massive columns of smoke altering the world's climate for years, devastating the ozone layer, and endangering human health and food supplies. Depleted uranium, used in armour-piercing projectiles and tank shells, presents another example. While effective in destroying armoured vehicles, it emits low-level radiation and contaminates soil, water, and air, leading to health problems such as kidney damage, lung cancer, and birth defects for those exposed.

3.3.Resource Exploitation and Social Injustice

Chemistry can be weaponized to manipulate and exploit natural resources for war, resulting in environmental degradation and social injustice. Agent Orange, used by the US in Vietnam to defoliate forests and crops, not only exposed and destroyed enemy hiding places but also contaminated soil, water, and the food chain, causing widespread health problems. The use of coltan, a mineral mined in the Democratic Republic of Congo, exemplifies resource exploitation. Armed groups control the mines, exploiting workers, often children, to extract tantalum, a rare metal used in electronic components. This trade fuels conflict and violence, claiming millions of lives and displacing millions more. Landmines, designed to create barriers or protect military installations, remain active for decades after wars, causing injuries and deaths to civilians and animals. This further highlights the lasting impact of chemistry on the post-war environment. The negative impacts of chemistry on war are a sobering reminder of its dual nature. While chemistry has brought about

remarkable advancements that benefit humanity, its role in warfare raises ethical questions and demands a careful examination of the consequences. The destructive power of weapons, the unintended and long-term repercussions, and the exploitation of resources underscore the need for responsible scientific and military practices. As we explore the positive potential of chemistry, it is essential to acknowledge and address the dark side, striving for a future where scientific advancements contribute to peace, sustainability, and the well-being of our planet. Chemistry, with its immense potential for both creation and destruction, plays a pivotal role in the landscape of warfare. The impact of chemistry on war is not limited to the development of weapons; it extends to the treatment of diseases, environmental considerations, and ethical implications. The duality of chemistry in warfare raises complex challenges and dilemmas, underscoring the need for responsible and ethical use to ensure the well-being of humanity and the planet [8-11].

3.4.The Challenges and Dilemmas

Chemistry's dual nature is reflected in its ability to create, enhance, or counter weapons and technologies, as well as to treat, prevent, or cause diseases and injuries. On one hand, it contributes to the development of life-saving medicines, protective materials, and innovative technologies that enhance military efficiency and safety. On the other hand, chemistry has been harnessed to create destructive weapons of mass destruction, chemical warfare agents, and environmental pollutants that pose severe risks to human health and ecosystems. The use of chemistry in warfare introduces multifaceted challenges and dilemmas that demand careful consideration. The risk of proliferation, misuse, and accidents associated with chemical weapons raises concerns about global security and stability. Responsibility and accountability become critical factors as state and non-state actors engage in the development and deployment of chemical weaponry. Striking a balance between security imperatives and human rights adds another layer of complexity to the ethical considerations surrounding chemical warfare. A central issue in the ethical use of chemistry in war lies in the responsibility of the actors involved.

Governments, military organizations, scientists, and industries all share a collective responsibility to ensure that chemical knowledge and capabilities are employed for constructive purposes. This requires stringent measures to prevent the unauthorized access and use of chemical weapons, as well as a commitment to transparency in research and development. Despite the challenges, the responsible and ethical use of chemistry in war is imperative for the welfare of humanity and the planet. The positive potential of chemistry lies not only in its ability to advance military capabilities but also in its capacity to address global challenges such as disease, environmental degradation, and resource scarcity. By harnessing chemistry for peaceful and beneficial applications, societies can mitigate the negative impacts associated with warfare. Chemistry's influence extends beyond the battlefield to environmental, social, and ethical dimensions. The production and use of chemical agents in warfare have far-reaching consequences for ecosystems, posing risks of contamination and long-term environmental damage. Socially, chemical warfare can lead to widespread health issues, displacement of populations, and the exacerbation of existing conflicts. Ethically, the use of chemical weapons raises questions about the morality of employing such destructive means in pursuit of military objectives.

Conclusion

It is easy to underestimate the central role of chemistry in modern society, where chemical products are essential for clothing, housing, and feeding the world's population. Beyond economic and utility considerations, progress in chemistry must now be measured by its environmental acceptability. The discovery and manufacture of new chemical goods must align with sustainability principles, ensuring that economic feasibility does not come at the cost of environmental degradation. Chemistry's impact on war is a nuanced and multifaceted phenomenon that encompasses both positive contributions and negative implications. As a powerful tool with the potential for both creation and destruction, chemistry demands responsible and ethical use. The challenges and dilemmas associated with chemical warfare necessitate a collective

commitment to promoting peaceful and beneficial applications, ensuring the well-being of humanity and the planet. Balancing progress, responsibility, and ethics in the realm of chemistry is crucial for shaping a future where scientific advancements contribute to peace, sustainability, and the betterment of society.

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